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WOODY PLANTS GROWTH ON ABANDONED AGRICULTURAL LANDS: SCALE, CAUSES OF ABANDONMENT, WAYS OF USE. A REVIEW

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The article presents an overview of Russian and foreign papers on the subject of quantitative assessment of woody plants growth on abandoned agricultural lands and possible ways to utilize them. Particular attention is paid to analysing the causes for the abandonment of such lands and the legislation issues that limit the provision of such areas for commercial forest growing in Russia. According to various estimates, the area of abandoned agricultural land in the world varies from 150 to 472 million hectares, with 33 to 100 million hectares being in Russia. At the same time, there is a trend towards an increase in the area of such lands. The rate at which the area of abandoned agricultural lands is increasing is about 1% per year on average. It may vary over time and depend on the region. The main groups of factors that contribute to the agricultural lands falling into disuse are social, economic, environmental, landscape and historical. The most promising is the involvement of such lands in climate-smart forestry activities, especially for agroforestry. This is due to the multiplier effect from, on the one hand, obtaining forest goods, including bioenergy, and on the other hand, services, including the use in crop or livestock farming activities. Currently in Russia there is no legislative framework permitting commercial forest growing on agricultural lands, with the exception of planting shelterbelts and other protective structures, despite the active position of organizations and government structures involved, so its development proves to be a necessity.

Keywords: *agricultural land, woody plants growth, woody plants growth factors, climate-smart forestry*

The generally recognized problem of climate change instigates interest in studying the potential of forest ecosystems for absorption and storage of greenhouse gases, including the search for ways to compensate for emissions using woody plants. For example, the new EU forest strategy for 2030 aims to plant an additional three billion trees on non-forest lands to achieve the goals of the European Union in biodiversity and reduce greenhouse gas emissions by at least 55% by 2030 (Novaja lesnaja strategija..., 2021). Russia has also committed to a 70% reduction in greenhouse gas emissions as compared to 1990 levels (Paris Agreement, 2015). In accordance with the Low-Carbon Development Strategy of the Russian Federation (Novaja lesnaja strategija..., 2021), Russia must compensate for 1.1 billion tons of CO_2 emissions to become carbon neutral by 2060.

Climate-smart forestry projects are recognized as one of the most important ways to achieve the goals of adaptation to climate change. In addition to climatic benefits, proper organization of such projects can support biodiversity, improve the protective functions of forests, increase the economic efficiency of the forest sector, and develop the local economy (Lesoklimaticheskie proekty..., 2021). The scientific community recognizes the use of abandoned agricultural lands for forest cultivation as one of the promising types of climate-smart forestry projects. The grounds underlying the use of such territories include a low baseline, significantly large areas of these territories, and their multiplier effect, which can bring benefits to the economy and environmental conservation (Rezoliutsiia..., 2021). The signing of the Glasgow Declaration on Forests and Land Use has also contributed to the relevancy of involving abandoned agricultural lands in forest climatic activities (Iurgens, Turbina, 2022). The countries that joined the Declaration, including Russia, identified the transition to sustainable land use as a key area for conservation and restoration of forests, for which national agricultural strategies and programs should be adjusted if necessary. Nevertheless, the contribution of woody plants of such forests to the national and global carbon budget remains unaccounted for, which poses a huge problem (Zomer et al., 2016). Therefore, it is vital to assess areas covered with woody plants on abandoned agricultural lands and analyse the factors of their formation to understand the carbon-depositing potential of such areas and possible ways of their involvement in climate-smart forestry activities.

Currently, it may be challenging to estimate the areas of abandoned agricultural lands, the composition and structure of vegetation on them on a global scale due to the differences in measurement methods creating complications (Subedi et al., 2021); their formation factors may differ significantly, therefore they must be considered individually. Estimation may also be difficult because of different groups of researchers suggesting different interpretations of the term of abandoned agricultural lands (Haddaway et al., 2013). The classic definition of abandonment is termination of agricultural activity in a given area (Pointereau et al., 2008). The abandonment of agricultural lands can be final, incomplete, hidden or repetitive, and it represents a decrease in the intensity of agricultural activity over time (Prishchepov et al., 2021). The Food and Agriculture Organization of the United Nations (FAO) defines abandonment of agricultural land as termination of agricultural activities on agricultural land for a short or long period of time, as well as passive use of such land and evolvement of succession processes (Land Abandonment..., 2011; Terres et al., 2013; Analysis of land..., 2023). Decree of the Government of the Russian Federation No. 1482 dated 18/09/2020 About Signs of Non-Use of Land Plots from Agricultural Lands defines abandoned agricultural land as an area where at least 50% is covered with weeds and the remaining part is not operated, or the area is utilized by no more than 25%. In accordance with Federal Law No. 101-FZ dated 24/07/2002 On the Turnover of Agricultural Land, agricultural lands are recognized as non-utilized and withdrawn if the area has not been utilized for three or more consecutive years.

When analysing the potential use of such areas in climate-smart forestry projects, an integrated approach is needed taking into account alternative uses of abandoned agricultural lands to select the most rational ones. This approach serves as a basis to organize smart forestry, both for careful attitude to natural resources and for creating synergies with other fields of the forest-related economy (Kauppi et al., 2018).

This article is intended to discuss estimates of woody plants growth of abandoned agricultural lands, reasons for termination of agricultural activities, and existing areas of involvement of such lands in climate-smart forestry activities.

World Estimates of Woody Plants Growth on Abandoned Agricultural Lands

The current trend towards reducing agricultural land areas with their subsequent woody plants growth is global. The amount of abandoned agricultural lands worldwide in the period from 1700 to 1992 is estimated at 150 million hectares (Ramankutty, Foley, 1999). In the paper by J. Campbell et al., the area of abandoned agricultural lands is estimated at 385–472 million hectares (Campbell et al., 2008). During the 20th century, the largest number of agricultural lands were abandoned in North America, the former Soviet Union and

South Asia, followed by Europe, South America and China (Cramer et al., 2007).

In the paper by M. Gvein et al. (Gvein et al., 2023), a global assessment of the area of abandoned agricultural lands from 1992 to 2018 was made based on Earth's remote sensing (ERS). The total area of abandoned agricultural lands is estimated at 98 million hectares (fig. 1, a). There is an increase in the rate of abandonment of arable land from 3.6 million hectares a year^{-1} in the period from 1992 to 2015 to 4.8 million hectares a year^{-1} in the period from 2015 to 2018. According to the authors' forecast, by 2050 the area of such lands may increase to 168 million hectares (fig. 1, b).

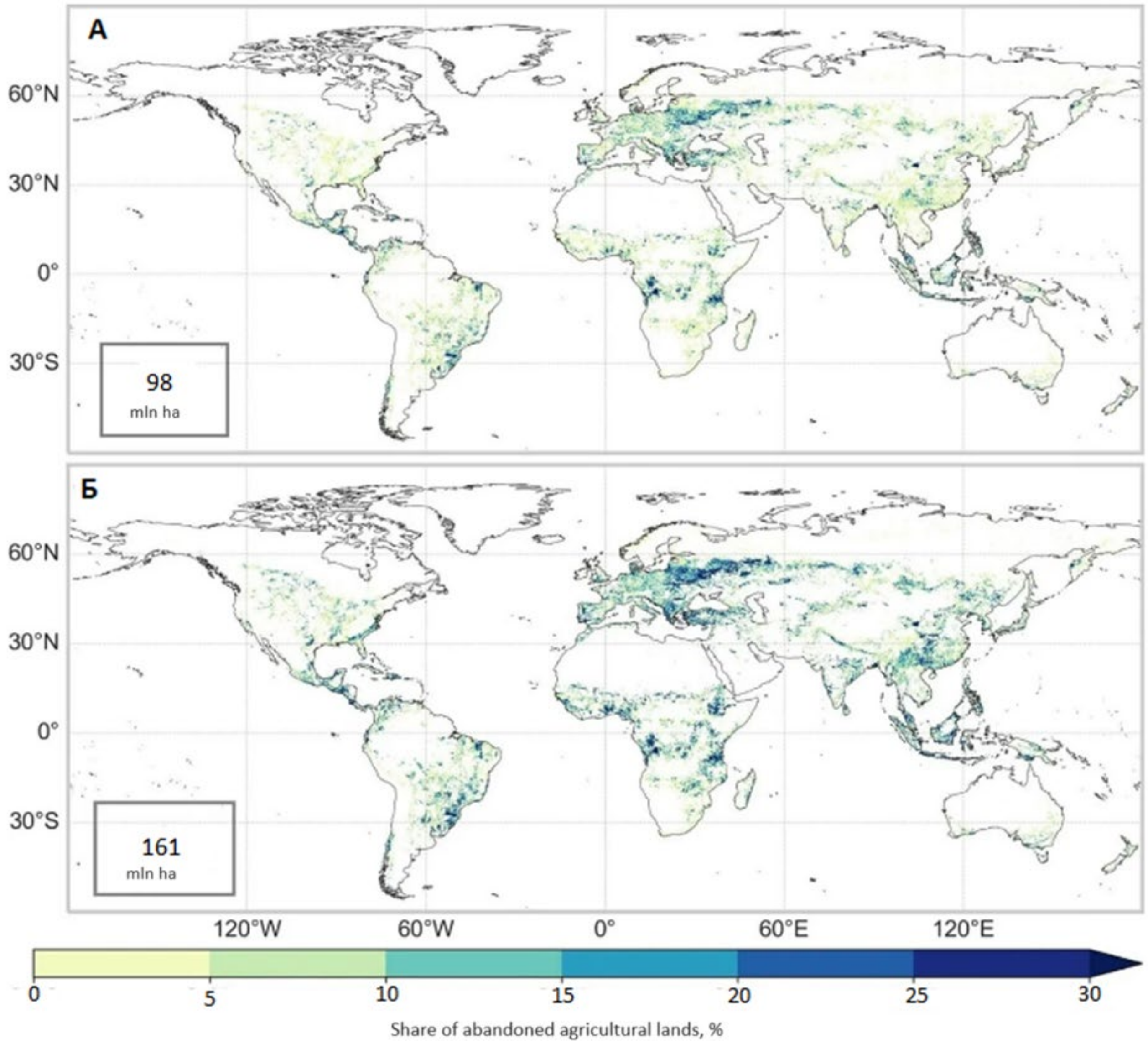

Figure 1. Dynamics of forest areas on abandoned agricultural lands (Gvein et al., 2023)

The reduction of agricultural land area is not always accompanied by abandonment. In some situations, agricultural land is seized for the needs of industry, and subsequently infrastructure facilities arise in these areas. However, D. I. Ljuri et al. (2010) emphasize in their paper that the impact of agricultural land seizure for construction in the period from 1961 to 2000 is significant for a small number of countries, such as Japan, India, the Netherlands, Belgium, and Germany.

In the mountainous regions of China, about 28% of arable land was abandoned during the first decade of the 21st century (Subedi et al., 2021). In particular, from 2000 to 2003, the area of abandoned agricultural lands covered with woody plants throughout China increased by 1.41 million hectares (Liu et al., 2010). In the abandoned agricultural lands of northern China with a total area of 72.48 thousand hectares in the period from 2003 to 2013, 20% of the territory underwent the processes of forest formation at different succession stages. During the same period, closed forests formed on an area of 7.92 thousand hectares (Wang et al., 2015).

According to estimates based on ERS data, in the period from 2002 to 2017, the share of abandoned agricultural lands within the area cultivated in 2000 throughout China averaged 5% (8.47 million hectares). Herewith, the smallest share of 3.7% was in 2002, and the largest share of 6.8% — in 2015 (Zhu et al., 2021). For about twenty of the thirty-four main agricultural regions of China, there is a declining trend in utilization of lands, including some of the main grain production areas, such as the North China Plain, the middle and lower reaches of the Yangtze River (Zhu et al., 2021).

It should be noted that, in China, the process of forest formation on abandoned agricultural lands is often not spontaneous, but is an agroforestry phenomenon. This is supported by a number of government programs. For example, in the period from 2000 to 2020, in Inner Mongolia, one of the regions with the most severe desertification and land degradation in China, land restoration projects were launched, such as the Beijing-Tianjin Sand Source Control Program, the Three-North Shelter Forest Program, the Program for Soil and Water Conservation, the Nature Reserves Program and the Grain for Green Program, which is by far the largest environmental restoration plan and rural development program in the world (Wuyun et al., 2022). The Grain for Green program is aimed at converting low-yielding arable lands on slopes, lands with severe desertification, erosion, or salinization of soil into forest lands by planting trees. As a result of this conversion, from 2000 to 2018, about 700 thousand hectares of forest lands were restored in the agro-pastoral ecotone of northern China, and Shaanxi Province showed the best results in restoring vegetation. Here, the vegetation cover in the areas covered by this project increased from 29.7% in 1998 to 42.2% in 2005 (Cao et al., 2009) and to 45% in 2018 (almost 660,000 hectares) (Pei et al., 2021). The vegetation coverage area of the Loess Plateau increased significantly, from 31.6% to 59.6%, in the period from 1999 to 2013 (Zhao et al., 2023). According to estimates, the involvement of 1% of lands intended for increasing the area of forests and reducing the share of marginal agricultural lands in this program will lead to an 0.26% increase in gross primary production (Qiu, Peng, 2022).

In tropical countries, such as Brazil, Peru, and Puerto Rico, significant areas of intact forests have been reduced using a slash-and-burn farming system. Logging in combination with the diverse land utilization cases, different land management methods and different biophysical characteristics of ecosystems (for example, soil fertility) creates a dynamic landscape mosaic consisting of remnants of mature and secondary forest plots of different ages and disruption history (Kammesheidt, 2002; Rozendaal et al., 2019). The share of secondary forests in tropical countries reaches 40% of the total forest area, and their formation rate amounts to about 9 million hectares per year^{-1} (Brown, Lugo, 1990). In the mountainous regions of southern Costa Rica, the proportion of forests of various successional stages on abandoned agricultural lands is 32%, or 13,440 hectares (Helmer et al., 2000). In Puerto Rico, during the decade starting in 1980, the area of abandoned agricultural lands covered with forest vegetation increased by 25,000 hectares and reached a total of 143,000 hectares. Most of these areas are abandoned coffee plantations (Lugo and Helmer, 2004). In Colombia, 71.8% of the area of primary mature forests has been cut down in the last 30–60 years in six landscapes, including the central (Magdalena) and eastern (Orinoco, Amazon and Catatumbo) regions of Colombia (Etter et al., 2005). Logging is required to obtain new agricultural lands, since the condition of the existing lands deteriorates over time due to overgrazing and soil compaction, which subsequently leads to the abandonment of lands and forest restoration on them. A mosaic of forests has formed in this area at various restoration stages.

Remote sensing data showed that the total area of abandoned agricultural lands in Europe is 128.7 million hectares, most of them associated with the dissolution of the USSR (Estel et al., 2015). Between 2001 and 2012, about 7.6 million hectares were abandoned, mainly in Eastern Europe, Southern Scandinavia and the mountainous regions of Europe (Estel et al., 2015). In the period from 1962 to 2019, the largest areas of abandoned agricultural land among the countries of the European Union were noted for Italy (7.53 million hectares), Spain (7.03 million hectares), and France (5.78 million hectares) (Barsukova et al., 2021). In France and Spain, over the past 100 years, the annual losses of utilized agricultural land amount to 0.17% and 0.8%, respectively (Keenleyside et al., 2010). In the Nordic countries, such as Denmark, Estonia, Finland, Latvia, Lithuania, Sweden, up to 1.8–2.6 million hectares of agricultural land are forested (Rytter et al., 2016). The maximum increase in the area of abandoned agricultural lands in Europe was observed in 1990–2000, which is again associated with the USSR dissolution. For instance, over the period from 1990 to 2000, the increase in the area of abandoned agricultural lands was 42% in Latvia, 31.1% in Russia, 28.4% in Lithuania, 14.0% in Poland, and 13.5% in Belarus (Perepechina et al., 2016). In Latvia, the area of agricultural lands with woody plants may exceed 300,000 hectares. Timber reserves in these areas are estimated at 4.82 million m^3 (Liepins et al., 2008). In the Polish Carpathians, the area of abandoned agricultural lands grown over with woody plants is 13.9% (107.000 hectares); depending on the location, the areas vary from 1.7% to 38.4% of the region (Kolecka et al., 2017). In the border triangle in the Carpathians, which includes the territories of Poland, Slovakia and Ukraine, from 1998 to 2000, the area of secondary woody plants on abandoned agricultural lands increased by 161 thousand hectares (12.5%) (Kuemmerle et al., 2008).

The largest increase in such areas is characteristic of Slovakia, amounting to 119,000 hectares (20.2%) (Kuemmerle et al., 2008; Prishchepov et al., 2012). In western Ukraine, the area of abandoned agricultural lands reached 660,000 hectares in 2008 (Baumann et al., 2011). In their paper, D. I. Ljuri et al. (2010) note that, in the former USSR, the area of agricultural lands has been declining since 1970, mainly in the non-chernozem zone of the European Russia, Western Siberia and the Urals. The area of agricultural lands in these regions fell down from 1970 to 1990 and amounted to 8.6 million hectares, which was mainly caused by the reduction in the rural population in the post-war years and unfavourable soil and climatic conditions.

The regions posing the highest risk to become abandoned are the mountainous regions of Finland, Sweden, the Pyrenees, north-western Spain, Portugal, the central massif of France, the Apennines in Italy, the Alps, the mountainous regions of Germany, and the border region of the Czech Republic (Keenleyside et al., 2010). According to some forecasts, by 2030 the amount of abandoned agricultural land in European countries will reach 4.8–5.6 million hectares (fig. 2) (Castillo et al., 2018, European Commission..., 2021), while according to others, by 2040 the area of abandoned agricultural lands in Europe will amount to 7.1–21.2 million hectares (Janus, Bozek, 2019).

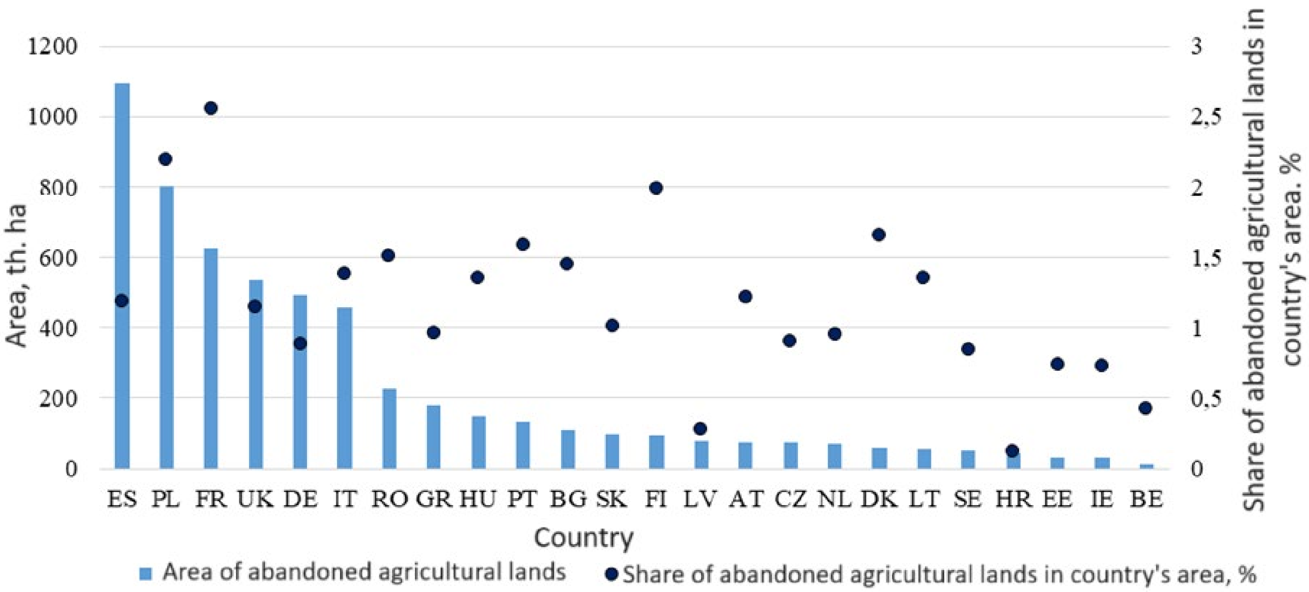

Figure 2. Predicted areas of abandoned agricultural lands by 2030 for European countries (according to Castillo et al., 2018)

Since mid-19th century, agricultural lands in the north-eastern regions of the United States have ceased to be utilized due to competition with agriculture in the Midwest and the Great Plains. About 75% of agricultural land was abandoned between 1880 and 1997 (Lana-Renault et al., 2020). For example, in Tompkins County, with an area of 125,000 hectares, forests were actively cleared during the 18–19th centuries, which reached its peak by 1900. By early 20th century, many farmers began to abandon the fields in search of better farms or more profitable jobs elsewhere. Since then, forests have continued to recover, occupying 54% of the county's land area by 1995. By 2005, the local landscape consisted of mature secondary forests, in which the native beech forests were replaced by pine, maple and ash (Flinn et al., 2005). According to some estimates (Zumkehr, Campbell, 2013), the area of abandoned agricultural land in the United States by 2000 was 68 million hectares, which is consistent with another study (Yu et al., 2019), in which the area of abandoned arable land in the period from 1980 to 2016 is estimated at 38.1–48.1 million hectares.

Woody Plants Growth on Abandoned Agricultural Lands in Russia

The socio-economic crisis that hit domestic agriculture in the early 1990s resulted in a situation where many arable lands, hay fields and pastures ceased to be utilized (Maslov et al., 2016). Thus, the area of agricultural lands of the Russian Federation in 1990 was estimated at 639.1 million hectares (Barsukova et al., 2021). According to official data, it amounted to 400 million hectares in 2010 and 381.7 million hectares in 2020 (Doklad o sostojanii i ispol'zovanii zemel'..., 2021).

Forest communities have formed on many abandoned areas in 25–30 years. However, there is currently no unified accounting system for woody plants growth of abandoned agricultural lands, which is why the estimates of such growth by different authors are ambiguous. According to various estimates, the area of abandoned agricultural lands in Russia where woody plants have grown ranges from 33 million hectares (Bartalev, 2023) to 100 million hectares (Greenpeace[1]..., 2018). Estimates based on Greenpeace[1] models are constructed without taking into account Siberia and the Far East, therefore, the area of woody plants growth on abandoned agricultural lands may be significantly higher (Karta neispol'zuemykh sel'khoz zemel'..., 2018). Regional estimates of woody plants growth are also ambiguous. For example, the area of forested agricultural lands in Altai Krai is 2.65 million hectares according to Greenpeace[1] (Karta neispol'zuemykh sel'khoz zemel'..., 2018), and 1.1 million hectares according to Roslesinforg estimates (Roslesinforg: ploshchad zarosshikh..., 2022). The area of forested agricultural land is 2.04 million hectares in Perm Krai according to Greenpeace[1] (Karta neispol'zuemykh sel'khoz zemel'..., 2018) and 1.38 million hectares according to A. P. Belousova and I. V. Bryzhko (2021). Never-the-less, researchers agree that the most intensive processes of woody plants growth on abandoned agricultural lands occur in the Non-Chernozem zone of the European part of Russia (Ljuri et al., 2010; Medvedev et al., 2019).

One of the most extensive databases on the areas of woody plants growth on abandoned agricultural lands is the Greenpeace[1]

[1]Since 19 May 2023, the Prosecutor General's Office of the Russian Federation has recognized the activities of this organization as undesirable in the Russian Federation.

map published in 2018 (Karta neispol'zuemykh sel'khoz zemel'..., 2018). The largest areas of woody plants growth since 2015 are observed in Novosibirsk Oblast (4.04 million hectares), the Republic of Bashkortostan (3.24 million hectares), Kirov (1.45 million hectares), Tver (0.81 million hectares) and Smolensk (0.79 million hectares) Oblasts (fig. 3). In most cases, agricultural activities are ceased due to remoteness of these territories from the central regions, low transport development, and outflow of population from rural areas. At the same time, the largest share of woody plants growth within the area of the region is typical for Smolensk Oblast, which is 35% (0.7 million hectares). The total reserves of timber in the abandoned agricultural lands of Russia are estimated at 300 million m^3. Its use can significantly reduce the anthropogenic load on newly cultivated boreal forests (Karta neispol'zuemykh sel'khoz zemel'..., 2018).

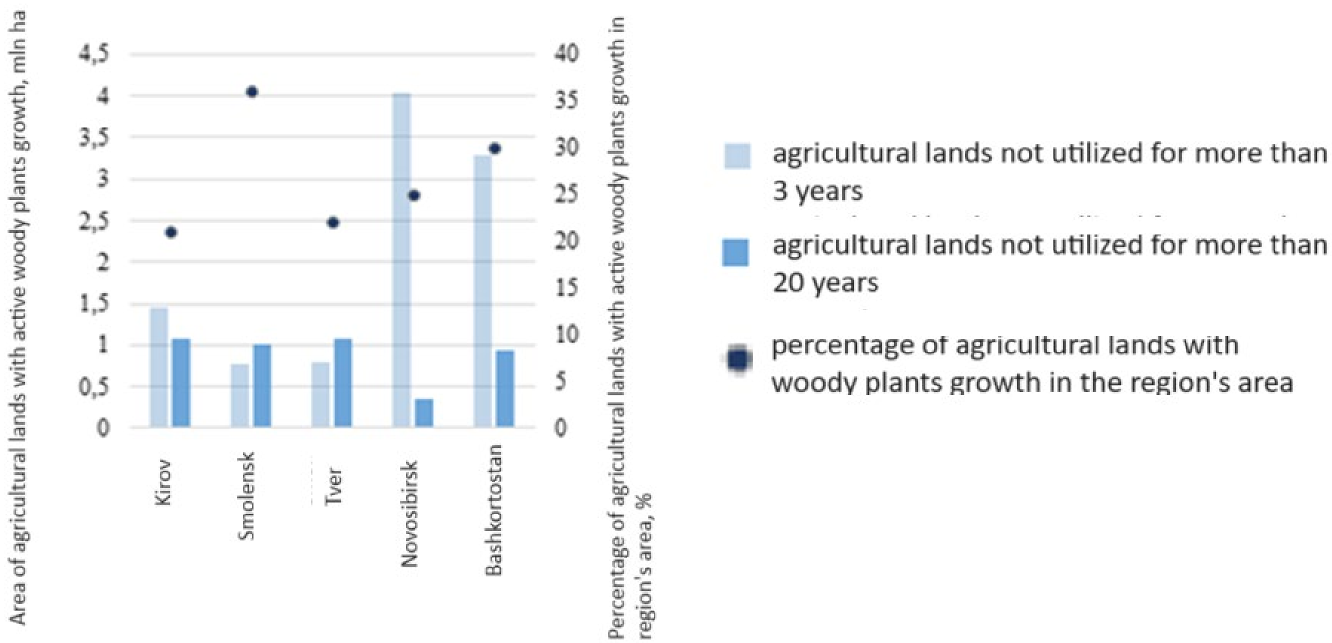

Figure 3. Woody plants growth area in abandoned agricultural lands of the Republic of Bashkortostan, Novosibirsk, Tver, Smolensk and Kirov Oblasts (Karta neispol'zuemykh sel'khoz zemel'..., 2018)

According to the estimates of the Space Research Institute of the Russian Academy of Sciences (Bartalev, 2023), the area of forests on abandoned agricultural lands increased by 5.8 million hectares from 2001 to 2021 and amounts to 32.9 million hectares. The average rate of increase in the area of forests on abandoned agricultural lands is about 125,000 hectares per year^{-1} (fig. 4). Accordingly, the carbon stock on such lands has increased by 0.3 billion tons since 2001 and amounts to 1.9 billion tons by 2020. The predominant species on abandoned agricultural lands is birch, growing on an area of 14.97 million hectares. Pine and larch grow on an area of 5.35 and 4.69 million hectares of abandoned agricultural lands, respectively (Bartalev, 2023). It is note-worthy that such forests are more productive than forests growing on forest lands. Thus, the distribution of forests on forest lands by bonus classes is 5.4%, 6.2%, 11.4%, 16.6% and 60.3%, starting from the first and ending with the fifth, while the distribution by bonus classes for woody plants growth on abandoned agricultural lands is 17.5%, 15.0%, 20.6, 20.3, and 26.7%, respectively (Bartalev, 2023). The average annual rate of increase in carbon stocks on abandoned agricultural lands is 26×106 Mt C per $year^{-1}$ (fig. 5) (Bartalev et al., 2021; Bartalev, 2023).

According to some estimates (Kurganova et al., 2014), the area of abandoned agricultural lands in Russia is estimated at 45.5 million hectares, the average rate of carbon accumulation in the upper 20-centimeter soil layer is 0.96±0.08 mg CO_2 ha^{-1} $year^{-1}$ during the first 20 years after agricultural activities are terminated, and 0.19±0.10 mg of CO_2 ha^{-1} $year^{-1}$ during the next 30 years. Consequently, the amount of carbon accumulated from 1990 to 2009 is 811.4 million tons. Said amount includes 267.9 million tons, 294.5 million tons and 249 million tons in the Northern European, Southern European and Asian parts of the country, respectively. Most carbon is accumulated in the Volga region (191.9 million tons), Western (108.3 million tons) and Eastern Siberia (106.4 million tons), as well as in the Urals (106.4 million tons) (fig. 6). In their papers (Kurganova et al., 2014, 2015), the authors emphasize that factors such as soil type, forest-forming rock and the age of abandonment of the site have a significant impact on carbon deposition.

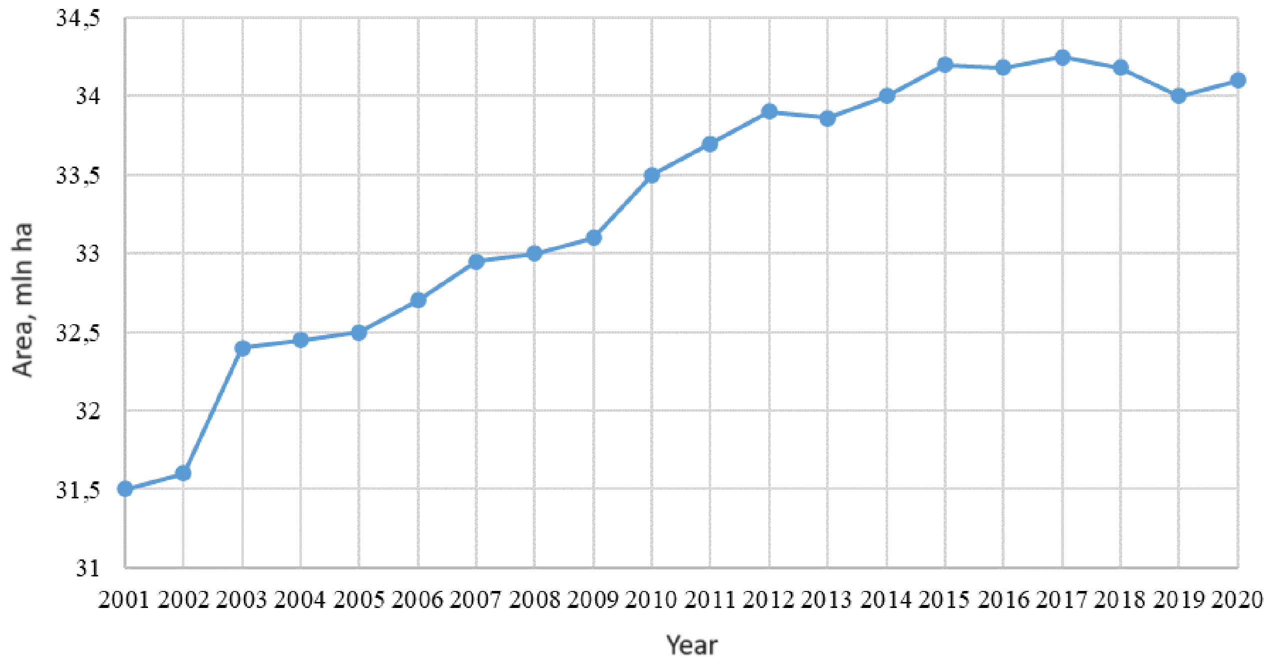

Figure 4. Dynamics of forest areas on abandoned agricultural lands (according to Bartalev, 2023)

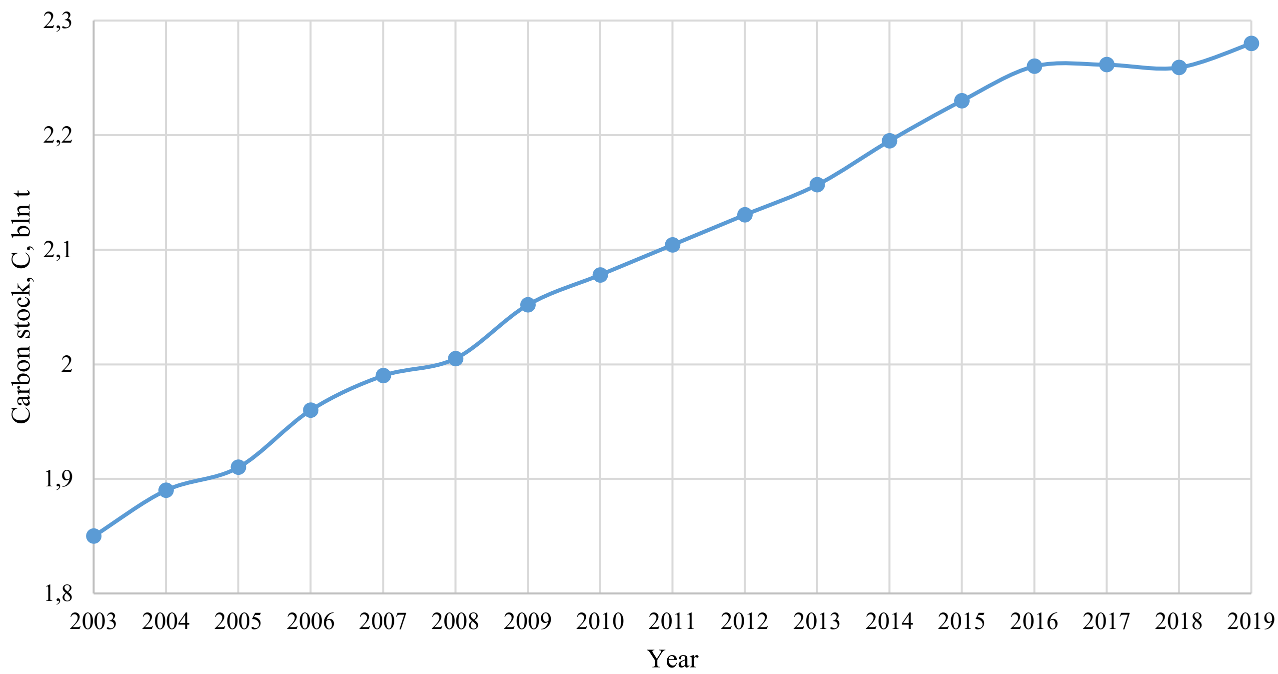

Figure 5. Carbon stock in the forest phytomass outside the forest lands (according to Bartalev, 2023)

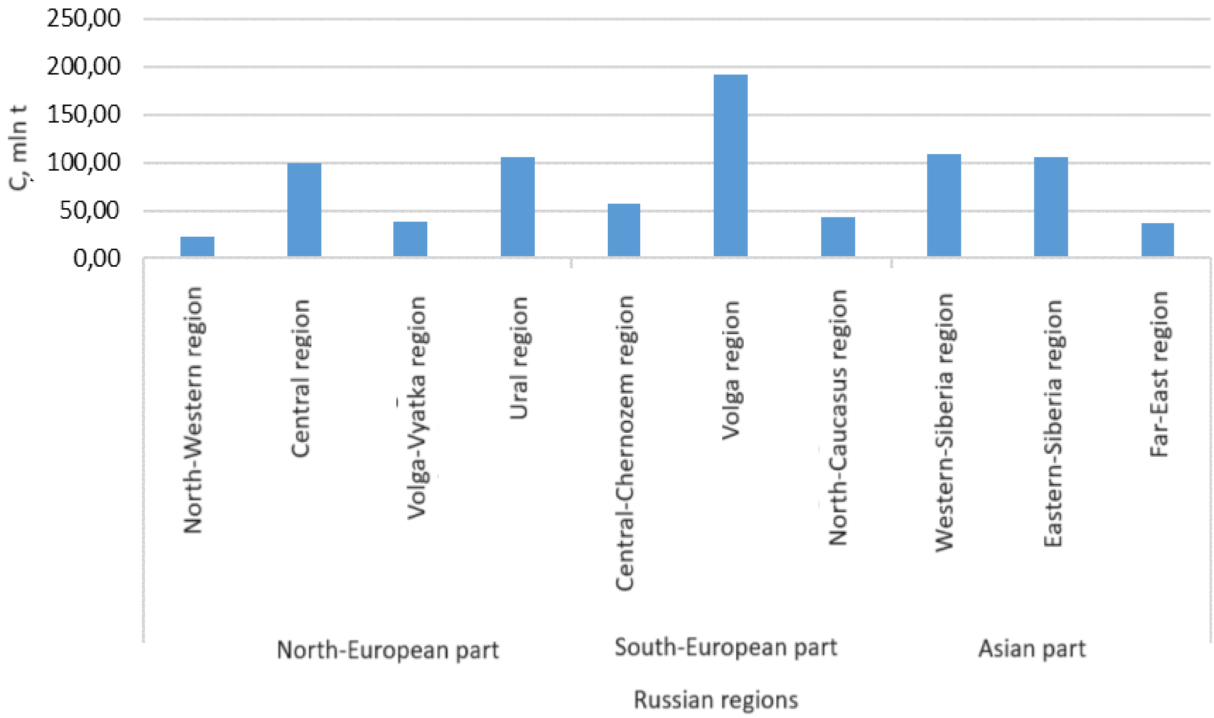

Figure 6. Carbon deposition in the twenty-centimetre soil layer of abandoned agricultural lands in the period from 1990 to 2009 (according to Kurganova et al., 2014)

In their subsequent paper (Kurganova et al., 2015), the authors note that the amount of abandoned arable land after 2005 remains constant and is 45.5 million hectares for Russia and 12.9 million hectares for Kazakhstan. For these territories, the net eco-system production (NEP) is 106 Mt C per year^{-1} and 125 Mt C per year^{-1}, respectively. The authors emphasize that the European part of Russia (ecoregions of taiga, coniferous-deciduous forests and forest-steppe) accounts for 44% of the total carbon stock provided by the termination of agricultural activities on arable lands.

Generalized data on the areas of abandoned agricultural lands are shown in table 1.

Reasons for Abandonment of Agricultural Lands

There are a significant number of publications analysing the causes of abandonment of agricultural lands and formation of forests on them for European countries where this phenomenon has been widespread since mid-20th century (Cramer et al., 2007; Prishchepov et al., 2013; Goga et al., 2019; Heider et al., 2021). The main reason for abandonment is unprofitability of agricultural activities on such lands, the limiting factors for which and their significance can vary significantly and should be considered individually on a case-by-case basis. The main groups of factors determining the abandonment of agricultural lands include social, economic, environmental, landscape and historical factors, or combinations thereof (Estel et al., 2015; Lasanta et al., 2017).

Table 1. Estimated areas of abandoned agricultural lands in different countries

Macroregion	Country/Region	Period, years	Area, mln hectares	Author
Globally		for 2008	385–472	Campbell et al., 2008
Globally		1700–1992	150	Ramankutty, Foley, 1999
Globally		1992–2018	98	Gvein et al.,2023
Southern, Northern, Eastern and Western Europe		2001–2012	128.7 covered by forest	Estel et al., 2015
Southern Europe	Mountainous areas of the Pyrenees	1900–2002	0.0054 covered by forest	Pueyo, Beguería, 2007
	Italy	1962–2019	0.00753	Barsukova et al., 2021
	Spain	196–2019	0.00703	Barsukova et al., 2021
Northern Europe	Denmark, Estonia, Finland, Latvia, Lithuania, Sweden	for 2016	1.8–2.6	Rytter et al., 2016
	Latvia	1990–1999	0.3–1.05 covered by forest	Liepins et al., 2008; Prishchepov et al., 2021
Western Europe	France	1962–2019	5.78	Barsukova et al., 2023
Carpathians	Poland, Slovakia, Hungary, Ukraine and Romania	for 2017	0.107 covered by forest	Kolecka et al., 2017
Eastern Europe	Russia	for 2022	33–100 covered by forest	Kurganova et al., 2014; Uzun, 2016; Greenpeace [1]..., 2018, Bartalev, 2023
	Ukraine	for 2008	0.66	Baumann et al., 2011
	Belarus	1990–1999	0.3375 covered by forest	Prishchepov et al., 2021
	Slovakia	1990–1999	0.119 covered by forest	Kuemmerle et al., 2008
	Poland	1990–1999	0.35	Prishchepov et al., 2021
Central Asia	Kazakhstan	for 2022	12.9 covered by forest	Kurganova et al., 2014
	Mountainous region of Nepal	for 2021	0.0103, of which 0.0028 are covered by forest	Subedi et al., 2021
East Asia	China	2000–2005	143 covered by forest	Liu et al., 2010
	China	2000–2017	8.47	Zhu et al., 2021
	Japan	2005–2015	3.6–4.6	Su et al., 2018
North America	USA	1850–2016	65	Yu et al., 2018
	Puerto Rico	for 2004	0.143	Lugo, Helmer, 2004
Central America	Mountainous areas of southern Costa Rica	for 2000	0.01344 covered by forest	Helmer et al., 2000

Environmental and landscape factors are closely related. These include unfavourable climatic conditions, negative land forms, low soil fertility, and a large number of erosion-prone areas (slopes, hills). The reason for ecosystem deterioration may be non-rational soil management and treatment systems, which lead to its degradation. Environmental and landscape factors are more fundamental in the abandonment of agricultural lands. In areas with an unfavourable climate and poor soils, urbanized territories are fewer and transport development is lower. Due to no infrastructure in such areas, there is an outflow of population, so farming becomes almost impossible, farmers do not cultivate such areas, and as a result, woody plant growth starts (Keenleyside et al., 2010; Peña-Angulo et al., 2019).

Social and economic factors are also closely linked. Socio-economic factors include low transport accessibility, distance from large market centres, outflow of rural population to cities, average size of cultivated areas, low economic importance of agribusiness, as well as lack of younger generation capable of supporting this industry, population decline, low life expectancy, etc. (Mottet, 2005). In socially marginal areas with a poorly developed economic component and a less demographically active population, the probability of abandonment of agricultural lands is higher than in areas with favourable socio-economic conditions. For instance, A. V. Prishchepov et al. (2021) as part of their study conducted a survey of agricultural producers from the Republic of Buryatia and found a rising interest in using abandoned lands among agricultural producers living in areas with a relatively high population density.

Economic factors include the government's pricing policy, which can lead to changes in the cost of raw materials, equipment, purchase prices for agricultural products, etc. Using the example of Perm Oblast (Zheljazkov et al., 2017), the authors show that the high cadastral and market value of abandoned agricultural land plots, combined with the population having no funds, can constitute important reasons for abandoning such lands. The authors propose that systems be introduced for calculating the economic efficiency and expediency of involving non-utilized agricultural lands. If it is impractical to use these territories in agriculture, a rational intersectoral redistribution of these lands is required to support their use with the help of state programs, for example, the Digital Economy Program of the Government of the Russian Federation (Zheljazkov et al., 2017).

The examples of historical factors include the dissolution of the USSR and the Second World War. These events had a significant impact on the economic and social stability of the Eastern Europe and Russia, thereby acting as determinants of the increased area of abandoned agricultural lands (Prishchepov et al., 2013). The first section of this article describes how the USSR dissolution caused an increase in the area of abandoned agricultural lands.

Scientific and technological progress (intensive farming model) also contributes to the termination of agricultural activities. Due to increased labour productivity and crop yields, farmers use less area to grow agricultural products. The remaining non-utilized areas are abandoned and grown over with woody and shrubby plants (Heider et al., 2021). Using the example of 190 countries from 1961 to 2003, D. I. Ljuri et al. (2010) showed that intensification can become one of the fundamental factors in reducing the area of agricultural land. After reaching a certain critical level of yield, agricultural land is reduced. According to the author, this phenomenon is due to the fact that expanding agricultural areas simultaneously with increasing their productivity is an expensive undertaking. With intensification, farmers tend to use the most productive lands to obtain greater efficiency from the intensification costs and, as a result, abandon less profitable lands. Also, intensification is usually associated with land degradation and its subsequent abandonment due to the environmental unsuitability thereof for agriculture (Ljuri et al., 2010). In addition, the study notes that attention should be paid not to the abandonment, but to the reduction in the rate of increase in the area under crops, since abandonment of plots in one region may be offset by an increase in agricultural areas in another. For instance, in the period from 1961 to 1965, the rate of increase in the area under crops was 10 times higher than in the period from 1995 to 2003. One example of this is the analysis of FAO data from 1970 to 2005 showing that the most common model of agricultural intensification was a simultaneous increase in the yield of agricultural crops and cultivated areas (Rudel et al., 2009).

It is apparent that a country's state policy directly affects its land utilization. In addition to the above-mentioned programs to combat desertification and land degradation in China, there are programs to support afforestation on marginal soils in African countries, such as the Great Green Wall (Good news for Africa's..., 2021); in European Union countries, such as the RURIS-AAL program in Portugal (Tomaz et al., 2013) and in other European countries, the Common Agricultural Policy Program in Italy (A greener and fairer cap, 2022); in Central America and in other countries, such as the Payments for Environmental Services Program in Costa Rica (Pagiola, 2008). An example of a major international project on utilization of marginal agricultural areas is the Bonn Challenge program (About The Challenge, 2017). The Bonn Challenge is a global effort to restore 350 million hectares of deforested and degraded land by 2030. Payment for ecosystem services programs are also in place in the Mediterranean. On the island of Sicily, with the abandonment of agriculture in favour of forest cultivation in marginal areas and agricultural reclamation, the organic carbon content in the 30-

centimeter soil layer increased by an average of 9.03 mg C ha^{-1}. Considering that the area of abandoned land is 14,300 hectares, CO2 emissions as a whole decreased by 15.3 mg of CO2 ha^{-1} year^{-1}. Over 20 years, farmers participating in these programs have received compensation payments from 9,100 euro at an absorption level of 5.2 mg C ha^{-1} to 46,600 euro at an absorption level of 26.7 mg C ha^{-1} (Novara et al., 2017).

Restitution processes, no market incentives, and changes in agricultural policy also contribute to the increase in the number of abandoned agricultural lands. A good example is the Eastern Europe, where, after the USSR collapse and transition to a market economy, significant changes took place in the political, socio-economic and demographic spheres, while state support and markets for agriculture disappeared, which led to the mass transfer of property rights. In fact, many landowners obtained their property by returning ownership rights to former owners or their successors during the land reform of the 1990s. They do not live on their property, but work in other sectors of the national economy and have neither the skills nor the knowledge or desire to work in the agricultural sector. This led to a large number of agricultural lands being abandoned. Most of these areas is currently covered with woody plants (Baumann et al., 2011; Prishchepov et al., 2013). One of the studies (Tomaz et al., 2013) highlights the leading role of political relationships and the availability of sales markets as the main factors in the reduction of agricultural land. As an example, the authors cite Cuba, where the sugar cane cultivation area decreased by 23% due to the loss of the sales market as a result of the Soviet Union collapse. The papers by A. P. Prishchepov (Prishchepov et al., 2012) show a close relationship between the extent of abandoned agricultural lands and the ability of states to adapt to institutional changes. The largest areas are typical of countries where the adaptation mechanism for handling abandoned agricultural lands has been shelved (the Baltic States and Russia) (Prishchepov et al., 2012).

Obviously, all the reasons are interrelated and must be analysed together. In this case, the "syndrome approach" developed by the Potsdam Institute for Climate Impact Research (Downing et al., 2002) can be used for a comprehensive analysis of the causes and consequences of abandonment of agricultural lands. It defines woody plant growth as a syndrome or a sign of certain social, economic, political or other environmental impacts. At the same time, the biophysical characteristics of the environment are a matrix that determines the extent of the syndrome. The area of land abandonment in this case is a measure of the syndrome manifestation. Using this approach, C. Weissteiner (Weissteiner et al., 2011) used meta-analysis to create a map showing the impact of socio-political processes on land utilization change in the period from 1990 to 2005 in the countries of the Mediterranean basin, taking into account the natural characteristics of each area. The authors used the integral indicator RLA (rural land abandonment), which varies from 0 to 1, 0 being the minimum abandonment of agricultural land and 1 being the maximum abandonment (fig. 7). The authors conclude that the abandonment of agricultural lands is a problem prevalent mainly in European countries, including Turkey. There is no apparent abandonment in the countries of North Africa and the Middle East. The countries of the Southern and Eastern Mediterranean show a trend towards abandonment, but at the time of the study, agricultural utilization prevails in these territories. In the countries of the Northern Mediterranean and some countries of the Middle East, land utilization changes are mainly determined by physical and environmental conditions, while for the rest of the countries both physical and environmental and individual socio-economic conditions play a role.

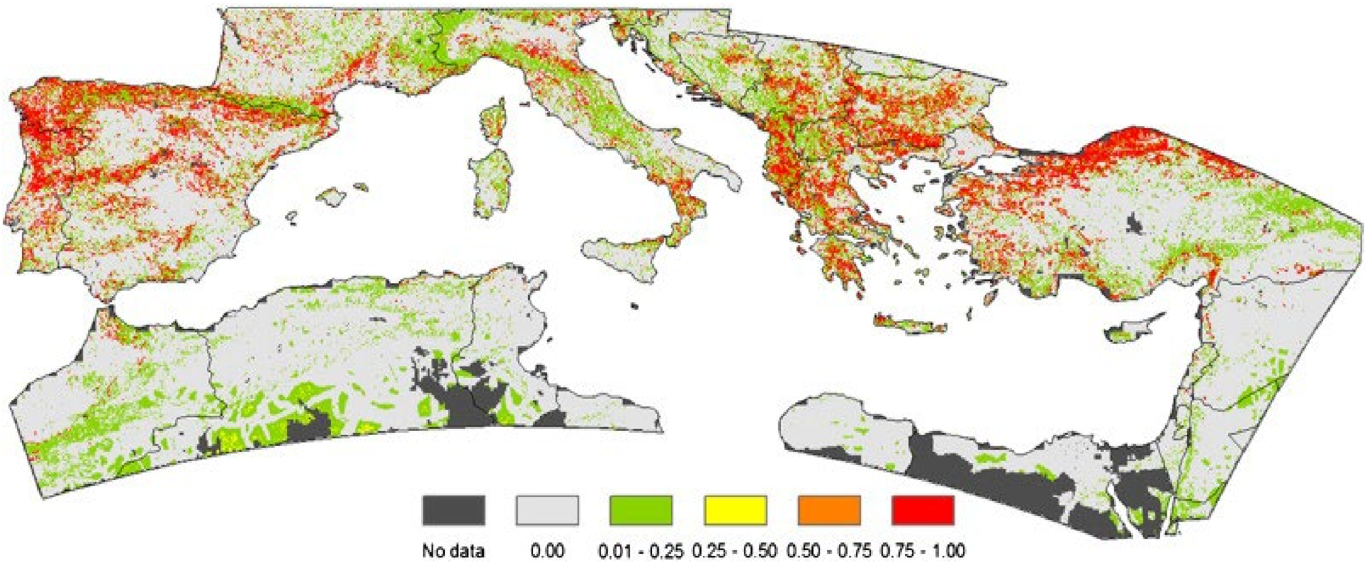

Figure 7. RLA assessment for the Mediterranean basin countries (Weissteiner et al., 2011)

Possible Utilizations of Abandoned Agricultural Lands

As compared to cultivated lands, abandoned agricultural lands are often low in fertility and require huge investments to clear them, especially ones in the non-chernozem zone of Russia; therefore, it is impractical to return such lands into agriculture (Pravitel'stvo zapretilo..., 2022). The use of forests on abandoned agricultural lands can become a significant and low-cost strategy for carbon sequestration and mitigation of anthropogenic CO_2 emissions (Post, Kwon, 2000; Novara et al. 2017; Rezoliutsiia..., 2021). The scientific community recognizes the significant role of the development of climate-smart forestry projects on abandoned agricultural lands (Rezoliutsiia..., 2021). This is also consistent with the objectives of the European Union's Forest Strategy for 2030 (European Commission..., 2021) and Russia's commitments to reduce greenhouse gas emissions to 70% compared to the 1990 level (Paris Agreement, 2015).

Forests grown on abandoned agricultural lands absorb CO_2 from the atmosphere, accumulating carbon in plant biomass and soil. As of 2010, 43% of all agricultural lands in the world had at least 10% of trees, the carbon content in the terrestrial phytomass of trees on agricultural lands is 47 billion tons, not including the carbon content of soils (Zomer et al., 2016); the same in Russia is 1.9 billion tons (Bartalev, 2023). The involvement of abandoned agricultural lands in climate-smart forestry activities in Russia will allow for an additional volume of greenhouse gas absorption of about 400 million tons of CO_2 year^{-1} (Rezoliutsiia..., 2021). Assessing the efficiency of using different types of tree species on abandoned agricultural lands in Sweden for the implementation of climatic scenarios showed that larch has the greatest climatic benefit (1.63 g CO_2 eq. ha^{-1}). Larch is followed by Norwegian spruce, poplar, hybrid aspen and birch in terms of carbon dioxide absorption efficiency, which demonstrate climatic advantages approximately 40–50% lower than that of larch. The climatic benefits were estimated based on the average annual increase using correction factors for carbon deposition in biomass, subsequent use of wood products and the turnover rate of growing stands (Lutter et al., 2021). A number of studies for the south-eastern region of Ontario, Abitibi and eastern Quebec compare the potential of using abandoned agricultural lands to adapt to climate change by assessing carbon reserves in soil and vegetation pools during natural succession and creation of forest crops (Foote, Grogan, 2010; Tremblay, Ouimet, 2013; Thibault et al., 2022). Thus, the following soil chronosequences were placed on the agricultural lands of Quebec with woody plants growth: 54 plantations (aged from 0 to 55 years) and 27 natural succession plots (aged from 0 to 45 years). Over 50 years, plantations deposited 31% more carbon than natural succession plots on average. The estimated rate of carbon accumulation by plantations is 1.7±0.7 mg C ha^{-1} year^{-1} higher than that in natural succession areas (Tremblay, Ouimet, 2013).

Forest communities both of natural or artificial origin formed on abandoned agricultural lands have a high level of productivity (Melekhov et al., 2011). According to experts, the annual growth in such territories in Russia is about 50 million m^3 per year^{-1} (Rezoliutsiia..., 2021). From the point of view of achieving climatic goals, the resulting wood biomass can be used for the production of long-lived materials and wood products or for bioenergy purposes.

The period of carbon conservation in timber is determined by the semi-decomposition period, i.e., the length of time within which half of the carbon contained in timber is returned to the atmosphere. The semi-decomposition period of cellulose and paper products is 1–2 years, while that of construction wood can be from decades to several hundred years (Zeng, Hausmann, 2022). Thus, the use of wood can represent a neutral carbon transfer to the products and contribute to the reduction of carbon emissions by providing a significant delay in emissions (Härtl et al., 2017). The study on the forest sector in Thuringia (eastern Germany) showed that long-lived hardwood products include furniture, parquet board, wood-based panels — for example, fibreboard and particle board — and coniferous construction wood. Herewith, about 53% of the total volume of wood harvested in the state forests of Thuringia is processed into wood products with an average service life of more than 25 years (Profft et al., 2009).

Wood grown on abandoned agricultural lands can be used to replace materials that use fossil fuels, such as plastics, steel and concrete (Kauppi et al., 2018). Studies in Sweden have shown that replacing a concrete frame in the construction of houses with long-lived building materials made of wood gives a greater climatic effect than when replacing fossil fuels with biofuels made of wood chips. Thus, the use of 1 ton of wood in a closed cycle of timber use with restoration of forest resources prevents the emission of 1.04 tons per day, which is an effective measure for carbon conservation and adaptation to change (Olsson, 2013). The Russian Federation can tap into the huge resource potential for the development of its own closed-cycle forest bioeconomy and cascading use of biomass, including wooden house construction, production of wood-based textiles, bioplastics, lignin, in addition to bioenergy (Forests of Russia..., 2020).

The use of forests on abandoned agricultural lands for bioenergy purposes can make a significant contribution to mitigating the climate change effects. One of the main ways to obtain biofuels may be using short rotation coppices (Aylott et al., 2008). There are up to 470 million hectares of abandoned or degraded agricultural lands worldwide that can be available for growing energy crops, based on dry biomass from 1.6 to 2.1 billion tons per year^{-1}, which is equivalent to 32 to 41 EJ of energy. This potential can provide up to 8% of global primary energy demand (Campbell et al., 2008).

In many countries of the world, abandoned agricultural lands are already being used to create energy plantations. For example, in Estonia, on abandoned agricultural lands, the energy productivity of 8-year-old birch plantations ranges from 70 to 80 GJ ha^{-1} year^{-1}, the energy potential of similar alder plantations averages at 145 GJ ha^{-1} year^{-1} (Uri et al., 2007). In Belgium, short rotation coppices of birch, maple, poplar and willow had, in the fourth year of cultivation, a biomass increase of 2.6; 1.2; 3.5 and 3.4 tons of dry matter ha^{-1} year^{-1}, respectively (Walle et al., 2007). In Italy and Albania, the average yield of dry biomass from short rotation coppices of Robinia pseudoacácia on abandoned agricultural lands was 1.96 t ha^{-1} year^{-1} (Kellezi et al., 2012). In the southern, central and northern agroclimatic zones of the Republic of Belarus, the average yield of willow plantations is 9.2 tons hectare^{-1} year^{-1}, with biofuels obtained in the third to fourth year after planting (Rodkin et al., 2016; Rodkin, Timoti, 2017). For willow plantations in Ireland, the yield varies from 10 to 14.5 t ha^{-1} year^{-1} depending on the climate, soil type, clone, growing conditions, etc. (Styles, 2007, 2008).

The study of A. R. Rodin and S. A. Rodin (2008) provides recommendations for the selection of breeds in the forest-growing zones of Russia for energy plantations. The authors recommend a thirty-year felling rotation for soft-wooded broadleaved species, since, for example, birch crops in Voronezh Oblast have the highest productivity in the first two to three decades, after which growth decreases sharply. The authors also show that creating energy plantations using soft-wooded broadleaved species makes it possible to conserve about 2 tons C ha^{-1} year^{-1}. Such data can be effectively used to assess the bioenergetic potential of abandoned agricultural lands (Rodin, Rodin, 2008).

The organization of energy plantations is of great importance. If mismanaged, the cultivation of energy crops can increase greenhouse gas emissions, adversely affect the environment and threaten biodiversity (Beringer et al., 2011; Langeveld et al., 2012; Pedroli et al., 2013). Such measures as continuous logging, harvesting of felling residues, low species diversity, and damage to the ground cover have a negative impact on the soil carbon accumulation. On the contrary, selective logging and low-intensity logging, abandonment of felling residues, and creating mixed forest plantations are promising forestry measures to conserve soil carbon (Tebenkova et al., 2022).

A significant part of the CO_2 absorbed by plants eventually accumulates in the soil, where it can be stored for a long time (Kuznecova, 2021). On average, the soil contains from 30% to 60% of the carbon reserves of forest communities (Nair et al., 2009; Framstad et al., 2013); the total carbon content in the 1-meter soil layer in the world is estimated at 1,500 Gt (Nair et al., 2009). Therefore, when developing climate-smart forestry projects on abandoned agricultural lands, carbon accumulation by soils may be of key importance. There are great differences in the rates of carbon intake and accumulation in soils, which are related to the productivity of regenerating vegetation, physical and biological soil conditions, as well as the past history of land utilization (Post, Kwon, 2000; Telesnina et al., 2017; Kuznecova, 2021). According to the meta-analysis (Post, Kwon, 2000), the rate of change in soil organic carbon during the woody plants formation on abandoned agricultural lands varies from small losses in the early stages of succession with a predominance of pine in the cool temperate zone to an increase of 300 g per m^2 year-1 in subtropical countries. The average rate of organic carbon input into the soil for forest communities on abandoned agricultural lands is 33.8 g/m^2 year-1 (Post, Kwon, 2000). Currently, the transformation and conservation of carbon in soils on abandoned agricultural lands of Russia are understudied. The existing studies mainly take into account only the arable horizon of soils (Vladychenskijj et al., 2013; Telesnina et al., 2017; Kurganova et al., 2018).

Experts are divided on the matter of achieving the greatest climatic effect from forest communities on abandoned lands to mitigate the effects of climate change. Some believe that the accumulation of carbon in forest biomass and soils is most efficient in the natural postagrogenic development of the ecosystem (Holtsmark, 2012). For example, the study by S. Lewis (Lewis et al., 2019) compares the formation of natural forests, creation of forest plantations and agricultural reclamation to assess the climatic benefits of the state Bonn Challenge program. If forests are formed naturally (natural reforestation), by 2100 they will store an additional 42 billion tons of C; if energy plantations are created, 1 billion tons; if agricultural reclamation is provided, 7 billion tons. Thus, it is shown that natural forests are 6 times more efficient at storing carbon than agricultural reclamation and 42 times better than plantations. The authors agree that plantations play a significant role in bioeconomics, and carbon reserves in plantations can be increased through more frequent harvesting of biomass, the use of diverse species or processing of wood into products with a longer service life (Lewis et al., 2019). On the other hand, the absence of forest management and no control over forests can contribute to more fires, foci of insects and fungal diseases. In conditions of increased demand for wood, reducing its production by climatically rational methods will contribute to an increase in imports from other regions where harvesting is done illegally or with environmental negligence. Therefore, the rejection of forestry measures may reduce carbon stocks in the forest stand and soils (Kauppi et al., 2018; Seidl et al., 2017) or breach the principle of no leakage (The Greenhouse Gas Protocol..., 2006).

The implementation of climate-smart forestry projects on abandoned agricultural lands, in addition to yielding climatic benefits, can contribute to the provision of other ecosystem services, for example, water regime control, soil ecological functions, and conservation of biodiversity. The multiplier effect of such areas can also be associated with economic benefits by providing additional jobs in rural areas, ensuring food security by obtaining additional forest resources, such as wood and non-wood forest products, without harming the environment (Rezoliutsiia..., 2021). In his work, A. N. Krivoshein (2016), proposes that an assessment be made of the environmental impact on forest systems when organizing energy plantations, taking into account the numerous ecosystem services that may be threatened. The author suggests that the sites be evaluated from the point of view of providing (commercial wood, wood biomass, non-wood and food resources, oxygen), regulating (cycles of nutrients, climate, water regime), supporting (soil formation, biodiversity maintenance) and recreational ecosystem services (Krivoshein, 2016).

Introducing sustainable and resource-saving methods for wood processing and consumption, while promoting carbon uptake by forests and improving forest growth, is the basis of the climate smart forestry concept (CSF) (Kauppi et al., 2018; Nabuurs et al., 2018). However, when implementing the CSF concept, specific measures and methods may differ significantly depending on national characteristics of forestry management and landscape and climatic factors. For example, the study of Czech forests showed that the optimal measure for long-term planning is to replace unstable spruce stands susceptible to loss under the influence of insects with stands of broad-leaved species (Nabuurs et al., 2018). In Spain, the key to increasing the uptake of CO_2 in forests is selective logging aimed at accelerating the growth of plantations and increasing their resistance to fires (Nabuurs et al., 2018). The authors emphasize the need for careful selective logging while keeping significant areas of high forest in order to maintain biodiversity. For the forests of Ireland, it is proposed to introduce additional efforts leading to investments in forestry as a way to mitigate CO_2 emissions (Nabuurs et al., 2018). Specific measures proposed by the authors include forming forest plantations consisting of 70% coniferous and 30% broad-leaved species, planting forests on soils with an underdeveloped organic horizon, and increasing the production of roundwood as a way of long-term carbon conservation. Under such scenarios, CO_2 uptake will increase in Spain by 0.6 million tons CO_2 year^{-1}, in Ireland by 1.4 million tons CO_2 year^{-1} within 50 years of modelling, and in the Czech Republic the amount of CO_2 emissions will increase by 1.3 million tons CO_2 year^{-1}, but in the long term, plantations will absorb more as compared to the baseline scenario.

One of the CSF options that appears to be the most promising when involving abandoned agricultural lands in climate-smart forestry projects is agroforestry (Rezoliutsiia..., 2021). Agroforestry is a system and methods of land utilization in which specially cultivated tree plantations are intentionally combined with agricultural crops and/or animals within the same agricultural landscape (Sanchez, 1995). From another point of view, agroforestry can be considered as stages in the development of an agroecosystem similar to the normal dynamics of natural ecosystems, i.e., an environmentally sound natural resource management system that diversifies and supports small-scale farming to increase social, economic and environmental benefits (Leakey, 1996). There are global practices for organizing agroforestry systems in marginal areas and on abandoned agricultural lands. Examples of such systems are socio-ecological industrial landscapes and seascapes, such as the manuel landscapes in Korea, dehesa landscapes in Spain, terroirs in France, satoyama landscapes in Japan, and infield/outland landscapes in Scandinavian countries (Berglund et al., 2014).

Legal Support for Utilization of Woody Plant Growth on Abandoned Agricultural Lands

A relevant problem of woody plant growth on abandoned agricultural lands in Russia is the legislative restrictions that almost completely prevent the use of such lands for forest cultivation, despite the fact that the risk of large fines or land withdrawal for the presence of woody and shrubby vegetation on it makes the involvement of such territories in forestry unprofitable (Les na sel'khozzemljakh..., 2022).

The current political situation around the issue of abandoned agricultural lands can be described as a "tug of war". On the one hand, there are legislative prerequisites allowing the conservation and cultivation of forests on agricultural lands, as evidenced by Federal Law No. 538 of 27 December 2018 On amendments to the Forest Code of the Russian Federation and Certain Legislative Acts of the Russian Federation in Terms of Improving the Legal Regulation of Relations Related to Ensuring the Conservation of Forests on Forest Fund Lands and Lands of Other Categories, which, from the point of view of the Forest Code of the Russian Federation, provides for the presence of forests on agricultural lands. Also, on 10 December 2019, the President of the Russian Federation instructed the Government to take measures aimed at establishing the specific features for the use, protection and reproduction of forests located on agricultural lands, which should enable all types of forest utilization on such lands without the need to change the form of land ownership and the category of land (V. Putin poruchil pravitel'stvu..., 2022).

On the other hand, on 21 September 2020, the Decree of the Government of the Russian Federation No. 1509 About the Peculiarities of the Use, Protection, Protection, Reproduction of Forests Located on Agricultural Lands was issued, regulating the specifics of the use, protection, and reproduction of forests, which, despite the fact that it implies the existence of forests on abandoned agricultural lands, is not consistent with Articles 77 and 78 of the Land Code of the Russian Federation. The resolution provides for the existence of exclusively protective and reclamation forest plantations on agricultural lands, thereby limiting the development of agroforestry. To resolve the current situation, the Scientific Council of the Russian Academy of Sciences on Forests sent a letter (Lesa, raspolozhennye..., 2022) to the Government of the Russian Federation with proposals to amend Resolution No. 1509 regarding the coordination of legislative acts for the cultivation of forests on abandoned agricultural lands. The Ministry of Agriculture of Russia does not agree with the proposals of the Scientific Council of the Russian Academy of Sciences on Forests because these lands should be utilized in accordance with their intended purpose (Lesa, raspolozhennye..., 2022).

Furthermore, on 8 June 2022, the Decree of the Government of the Russian Federation No. 1043 On Amendments to the Regulation on the Specifics of the Use, Protection, Protection, Reproduction of Forests Located on Agricultural Lands was formed, which makes forest cultivation on abandoned agricultural lands practically impossible. In particular, this provision introduces restrictions on the suitability of abandoned agricultural lands for forest cultivation, sets very strict limits on what constitutes a forest on abandoned agricultural lands, and does not allow the use of such lands for creating and exploiting forest plantations.

There are prerequisites to transferring such lands to the category of forest lands, as indicated by Roslesinforg's assessment of the areas of abandoned agricultural lands and land taxation on them (Roslesinforg: ploshchad zarosshikh..., 2022). In addition, amendments to Federal Law No. 101-FZ dated 24 July 2002 on the Turnover of Agricultural Land, which entered into force on 05 December 2022, significantly facilitate the process of seizing agricultural lands and transferring them to state ownership. Now, agricultural lands can be seized a year after signs of abandonment are detected (Les na sel'khozzemljakh..., 2022).

To overcome these bureaucratic barriers, Greenpeace[1] and the Scientific Council of the Russian Academy of Sciences on Forests propose that appropriate changes be made to Articles 77 and 78 of the Land Code of the Russian Federation (Rezoliutsiia..., 2021; Lesa, raspolozhennye..., 2022), and that a subsection "Forestry" be added in the classifier of types of permitted use of land plots and the presence of typical species of forest plants in forests and on lands used for forestry be excluded from the list of features defining abandoned agricultural lands (Vladimir Putin poruchil pravitel'stvu..., 2022). M. E. Rodina (2020) in her paper raises a number of important institutional and regulatory questions concerning the formation of a model of private forest management on abandoned agricultural lands with woody plant growth. In particular, when introducing private ownership of forest plots on abandoned agricultural lands, she proposes that the preservation of forests bordering rural settlements, garden associations, and small towns that are most important for preserving a favourable environment, be ensured, free and no-charge access be retained for the population to the collection, harvesting and use of non-wood products (mush-rooms, berries, etc.), as well as their recreational use, and subsidies be introduced for using forests on abandoned agricultural lands. The author also emphasizes the need to form regulatory legal acts that clearly define who is the owner of wood grown for commercial purposes on agricultural lands.

CONCLUSION

The reduction in the area of cultivated agricultural land is a global phenomenon that manifests itself not only in developing countries, but also in the countries with advanced economies. Over the past decade, extensive scientific research has been published on the extent of agricultural land abandonment at different spatial levels. The reasons for the termination of agricultural activities may be different: social, economic, environmental, landscape, and historical, but the most common one is a combination of ecological-landscape and socio-economic factors. Most often, abandoned lands are low-profitable due to the depletion of the fertile soil layer that often results in complete degradation of the landscape, and the great distance to large settlements where labour, production resources or points of sale of agricultural products are localized.

The abandoned areas show woody plants growth. This process is partially stimulated by government programs and is not spontaneous. The main motivation in this case is the fight against desertification and land degradation through forest cultivation. However, most often a young forest appears in an abandoned area during the natural succession of biogeocenoses. Returning the areas where forests have already been practically restored to the agricultural sector will have a notable effect both on the environment and on the landowner's budget. Therefore, it is necessary to focus on the rational use of such areas in economic activities.

Our research has shown that the involvement of overgrown abandoned agricultural lands in climate-smart forestry activities is very promising. In such areas, highly productive forest plantations can be grown, the woody biomass of which can be used in carbon-intensive industries such as plastics, concrete, and textile production, and for bioenergy purposes. The rational organization of forest plantations on abandoned agricultural lands subject to sustainable and resource-saving methods of processing and consumption of wood meets the principles of smart forestry. One of the options for this area of development, which was recognized as potentially effective for Russia, is agroforestry, in which specially cultivated tree plantations are intentionally combined with agricultural crops and/or animals within the same agricultural landscape.

The first step in returning abandoned agricultural lands on which forest ecosystems have been formed into active utilization is forming a regulatory framework and overcoming existing legislative restrictions. Currently, there is no legislative framework permitting commercial forest growing on agricultural lands, with the exception of planting shelterbelts and other protective structures, despite the active position of organizations and government structures involved.

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ЗАРАСТАНИЕ ЗЕМЕЛЬ СЕЛЬСКОХОЗЯЙСТВЕННОГО НАЗНАЧЕНИЯ ДРЕВЕСНОЙ РАСТИТЕЛЬНОСТЬЮ: МАСШТАБЫ, ПРИЧИНЫ, ПУТИ ИСПОЛЬЗОВАНИЯ. ОБЗОР

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В статье представлен обзор российских и зарубежных работ, посвященных количественным оценкам зарастания древесно-кустарниковой растительностью сельскохозяйственных земель и возможным путям их использования. Особое внимание уделяется анализу причин выбытия земель из пользования и проблемам законодательства, ограничивающим предоставление таких участков для лесовыращивания на территории России. По разным оценкам площадь заброшенных сельскохозяйственных угодий в мире варьирует от 150 до 472 млн га, в России — от 33 до 100 млн га. При этом отмечается тренд к увеличению площади таких земель. Скорость, с которой увеличиваются площади заброшенных сельскохозяйственных земель, в среднем составляет около 1% в год. Она может различаться во времени, а также зависеть от региона. Основные группы факторов, способствующие образованию таких территорий: социальные, экономические, экологические, ландшафтные и исторические. Наиболее перспективно вовлечение таких земель в лесоклиматическую деятельность, особенно для агролесоводства. Это связано с мультипликативным эффектом, с одной стороны, от получения лесных товаров, в т. ч. биоэнергетических, и, с другой стороны, услуг от использования в растениеводческой или скотоводческой деятельности. В настоящее время в России нет законодательной основы, разрешающей лесоразведение на землях сельскохозяйственного назначения, за исключением полезащитных насаждений, несмотря на активную позицию заинтересованных организаций и структур власти, поэтому необходима ее разработка.

Ключевые слова: *земли сельскохозяйственного назначения, зарастание, факторы зарастания, лесоклиматический проект*

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